part in producing the wonderful qualities of modulation and expression peculiar to the human voice. In animated conversation, declamation and singing, this may be seen.

"Its function then appears to be threefold—rendering the slack, mobile and flexible vocal organ or tube rigid, tense and inflexible, and fit to produce pure tone; by its bulk and density acting as a loader and strengthener, making the tone more sonorous, full and deep, and thus compensating for want of length and size in the organ; and finally, by its varying shape, bulk, density and pressure, furnishing an important aid in producing the inimitable qualities of modulation and expression enjoyed by the human voice.

"That it is a part of the organ of voice and an important accessory in giving it perfection, may be inferred also from its situation on the larynx and trachea, and its being supplied by the same nerves—its being largest in man, where the voice and speech are perfect—its being proportionally larger in women and children than in men, their smaller and more mobile organs requiring its peculiar aid. Among the lower animals, it is present (at least in a fully developed condition) only in the Mammalia, but among them there is a remarkable exception in the Cetacea—they have it not, and they have no voice. In Birds, which have such great power and modulation of voice, the structure of the vocal organ and tube is different from that in man, and sufficient in itself to produce these qualities.

"The importance of the thyroid body must be admitted when it is shown to be necessary for the perfection of the voice, and hence of speech—that great and indispensable agent in the cultivating and advancing the highest faculties of man."

II. "Experimental Researches on the Strength of Pillars of Cast Iron." By Eaton Hodgkinson, Esq., F.R.S., Professor of the Mechanical Principles of Engineering, University College, London. Received November 20, 1856.

(Abstract.)

In a previous paper on this subject (Philosophical Transactions, 1840), I had shown,—1st, that a long circular pillar, with its

ends flat, was about three times as strong as a pillar of the same length and diameter with its ends rounded in such a manner that the pressure would pass through the axis, the ends being made to turn easily, but not so small as to be crushed by the weight; 2nd, that if a pillar of the same length and diameter as the preceding had one end rounded and one flat, the strength would be twice as great as that of one with both ends rounded; 3rd, if, therefore, three pillars be taken, differing only in the form of their ends, the first having both ends rounded, the second one end rounded and one flat, and the third both ends flat, the strength of these pillars will be as 1—2—3 nearly.

The preceding properties having been arrived at experimentally, are here attempted to be demonstrated, at least approximately.

The pillars referred to in my former paper were cast from Low Moor iron No. 3; they were very numerous, but usually much smaller than those used in the present trials. I felt desirous too of using the Low Moor iron in the *hollow* pillars employed on this occasion, not on account of its superior strength, but its other good qualities. The pillars from this iron were cast 10 feet long, and from $2\frac{1}{2}$ to 4 inches diameter, approaching in some degree, as to size, to the smaller ones used in practice. The results from the breaking weights of these were moderately consistent with the formulæ in the former paper, with a slight alteration of the constants, rendered necessary by the castings being of a larger size, and therefore softer than before, a matter which will be adverted to further on.

The formulæ for the strength of a hollow pillar of Low Moor iron No. 2,—where w is the breaking weight, in tons, of a pillar whose length is l in feet, and the external and internal diameters D and d in inches, the ends being flat and well bedded—are as below:

$$w=46\cdot65\times\frac{D^{3\cdot55}-d^{3\cdot55}}{l^{1\cdot7}},$$

from formula in Phil. Trans. 1840;

$$w=42\cdot347\times\frac{D^{3\cdot5}-d^{3\cdot5}}{l^{1\cdot63}},$$

from formula in present paper.

To obtain some idea of the relative strengths of pillars of different British irons, I applied, at Mr. Stephenson's suggestion, to Messrs.

Easton and Amos, who procured for me twenty-two solid pillars, each 10 feet long and $2\frac{1}{2}$ inches diameter, cast out of eleven kinds of iron (nine simple irons and two mixtures). The pillars were all from the same model, and were cast vertically in dry sand, and turned flat at the ends, as the hollow ones had been ; two being cast from the same kind of iron in each case. The simple unmixed irons tried were as below, and all of No. 1.

		Mean breaking weight.
Old Park iron........	Stourbridge	29·50 tons.
Derwent iron	Durham	28·03 ,,
Portland iron	Tovine, Scotland	27·30 ,,
Calder iron..........	Lanarkshire	27·09 ,,
Level iron	Staffordshire	24·67 ,,
Coltness iron	Edinburgh	23·52 ,,
Carron iron..........	Stirlingshire	23·52 ,,
Blaenavon iron	South Wales	22·05 ,,
Old Hill iron	Staffordshire	20·05 ,,

The mean strength of the pillars from the irons above varies from 20·05 to 29·50 tons; or as 2 to 3 nearly.

The pillars formed of mixed irons were found to be weaker than the three strongest of the unmixed series.

From many experiments, it was shown that the weight which would crush the pillars, if they were very short, would vary as 5 to 9 nearly.

The pillars in general were broken of four different lengths, 10 feet, 7 feet 6 inches, 6 feet 3 inches, and 5 feet, the ends of all being turned flat, and perpendicular to the axis. It was found that when the length was the same, the strength varied as the 3·5 power of the diameter ; and when the diameter was the same and the length varied, the strength was inversely as the 1·63 power of the length. Both of these were obtained from the mean results of many experiments.

The formula for the strength of a solid pillar would therefore be

$$w = m \times \frac{d^{3\cdot5}}{l^{1\cdot63}},$$

where w is the breaking weight, d the diameter in inches, l the length

in feet, and m a weight which varied from 49·94 tons in the strongest iron we tried, to 33·60 tons in the weakest.

The ultimate decrement of length, in pillars of various lengths but of the same diameter, varies inversely as the length nearly. Thus the ultimate decrements of pillars 10 feet, 7 feet 6 inches, 6 feet 3 inches, and 5 feet, vary as 2, 3, $3\frac{1}{2}$ and 4 nearly, according to the experiments, from which it appeared that the mean decrement of a 10-feet pillar was ·176 inch.

Irregularity in Cast Iron.

The formulæ arrived at in this paper are on the supposition that the iron of which the pillars are composed is uniform throughout the whole section in every part; but this was not strictly the case in any of the solid pillars experimented upon. They were always found to be softer in the centre than in other parts. To ascertain the difference of strength in the sections of the pillars used, small cylinders $\frac{3}{4}$ inch diameter and $1\frac{1}{2}$ inch high, were cut from the centre, and from the part between the centre and the circumference, and there was always found to be a difference in the crushing strength of the metal from the two parts, amounting perhaps to about one-sixth. The thin rings of hollow cylinders resisted in a much higher degree than the iron from solid cylinders. As an example, the central part of a solid cylinder of Low Moor iron No. 2, was crushed with 29·65 tons per square inch, and the part nearer to the circumference required 34·59 tons per square inch; cylinders out of a thin shell half an inch thick, of the same iron, required 39·06 tons per square inch; and other cylinders from still thinner shells of the same metal, required 50 tons per square inch, or upwards, to crush them.

As these variations in cast iron have been little inquired into, except by myself, and have never, so far as I know, been subjected to computation, I have bestowed considerable trouble upon the matter, in an experimental point of view, and endeavoured to introduce into the formulæ previously given, changes which will in some degree include the irregularities observed.